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(72) Inventor	Colin John Macleod	(58) Field of search	UK CL (Edition J) E1F FWA FWDA FWDC FWDJB FWM INT CL ⁴ E21C, E21D, E21F
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(54) A mining method

(57) A method of mining is proposed wherein a series of sequentially augered/bored holes (4, 4a-n.) are produced leaving a pillar of coal (5) to form roof supports, the bored hole adjacent to that being worked is left open for ventilation passage (15), the next hole may be used for storing during the working cycle for elements of the borer/auger (17) the auger borer head (3a) and elements or the whole of the conveyor system (16), all other holes have both ends plugged (6) some forming a refuge hole (7) and some may be equipped with valves for combustion or water control. The pillars (5) may if the holes (4) etc are themselves packed and consolidated to form supports be augered/bored to yield coal to increase the overall production.

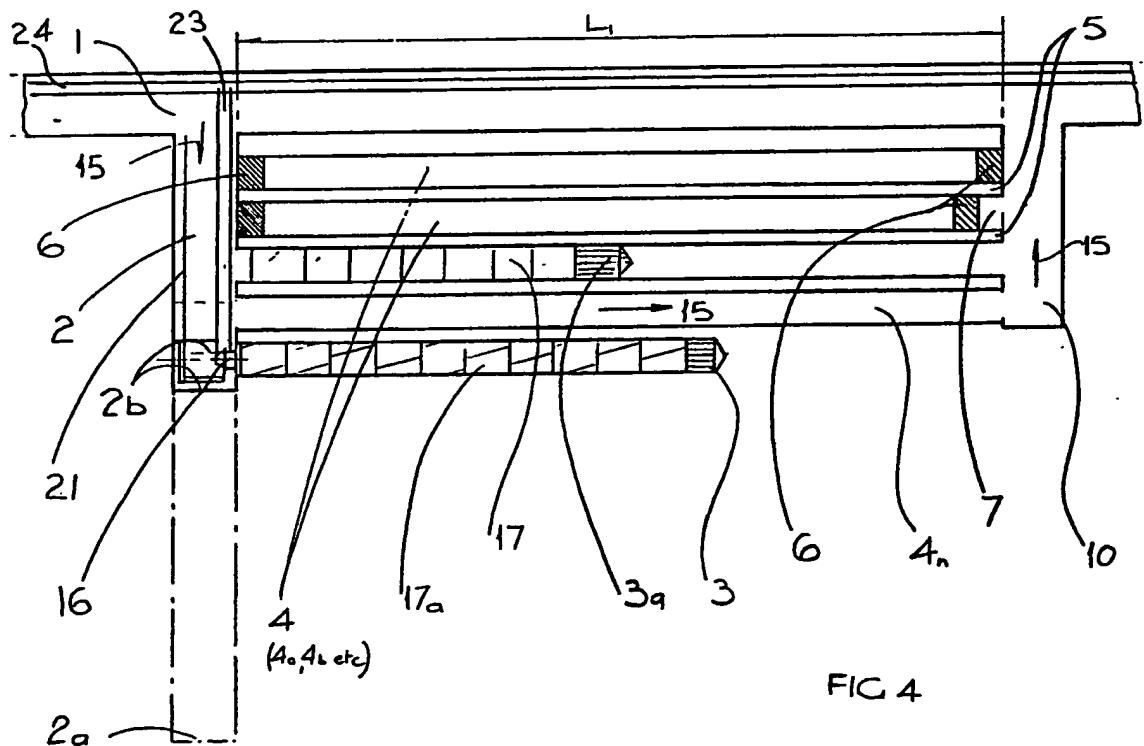


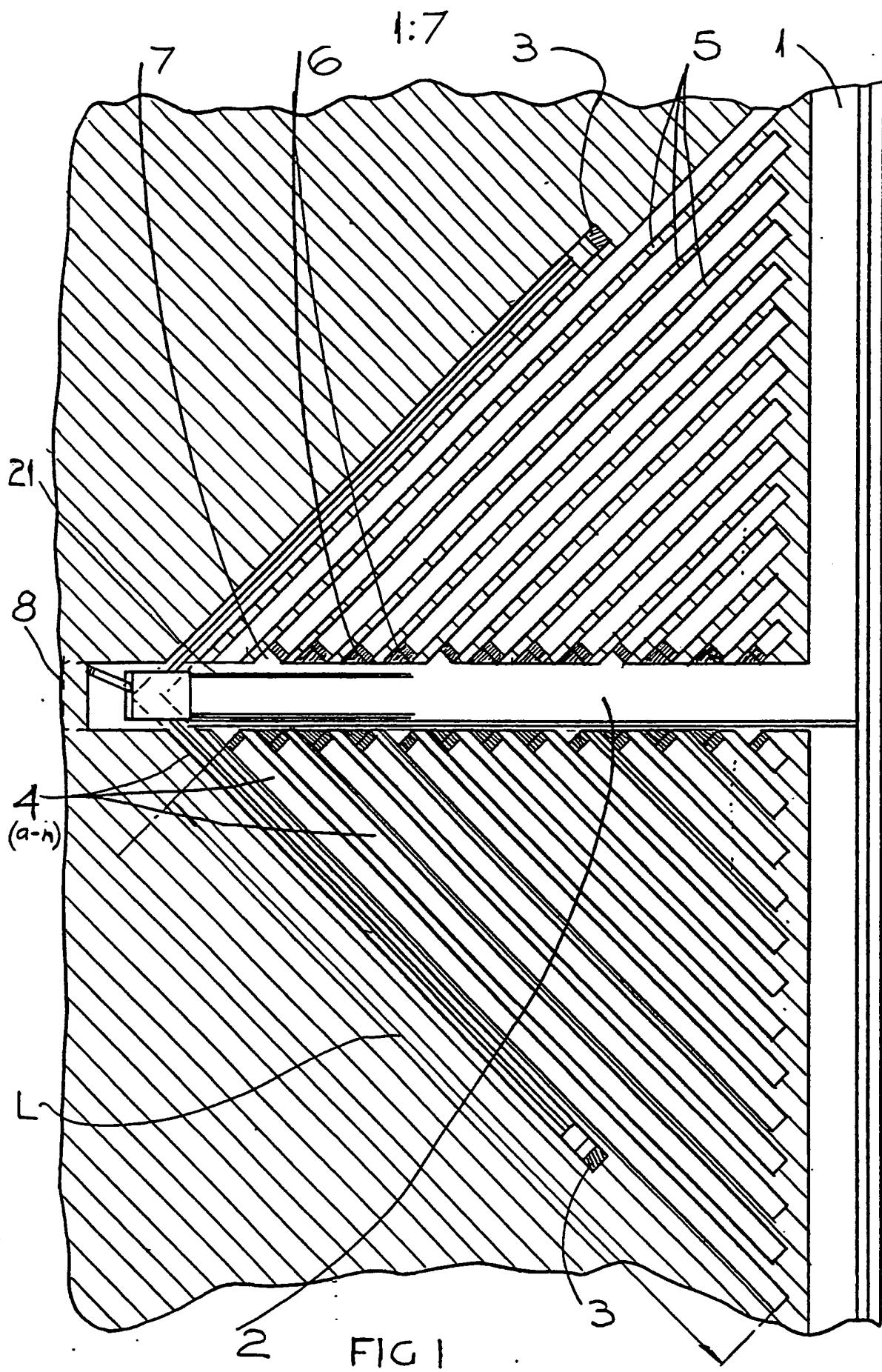
FIG 4

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1982.

This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

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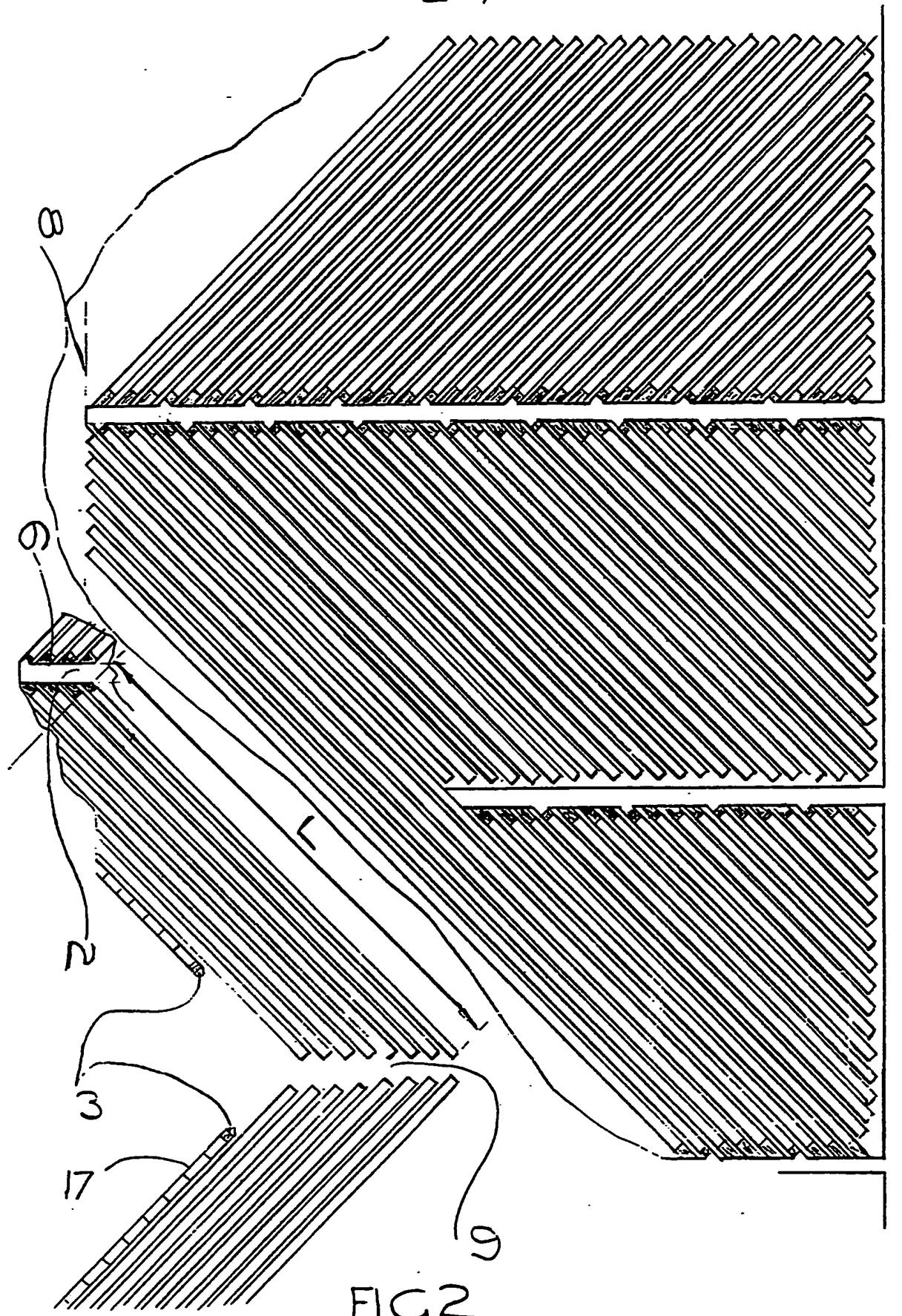
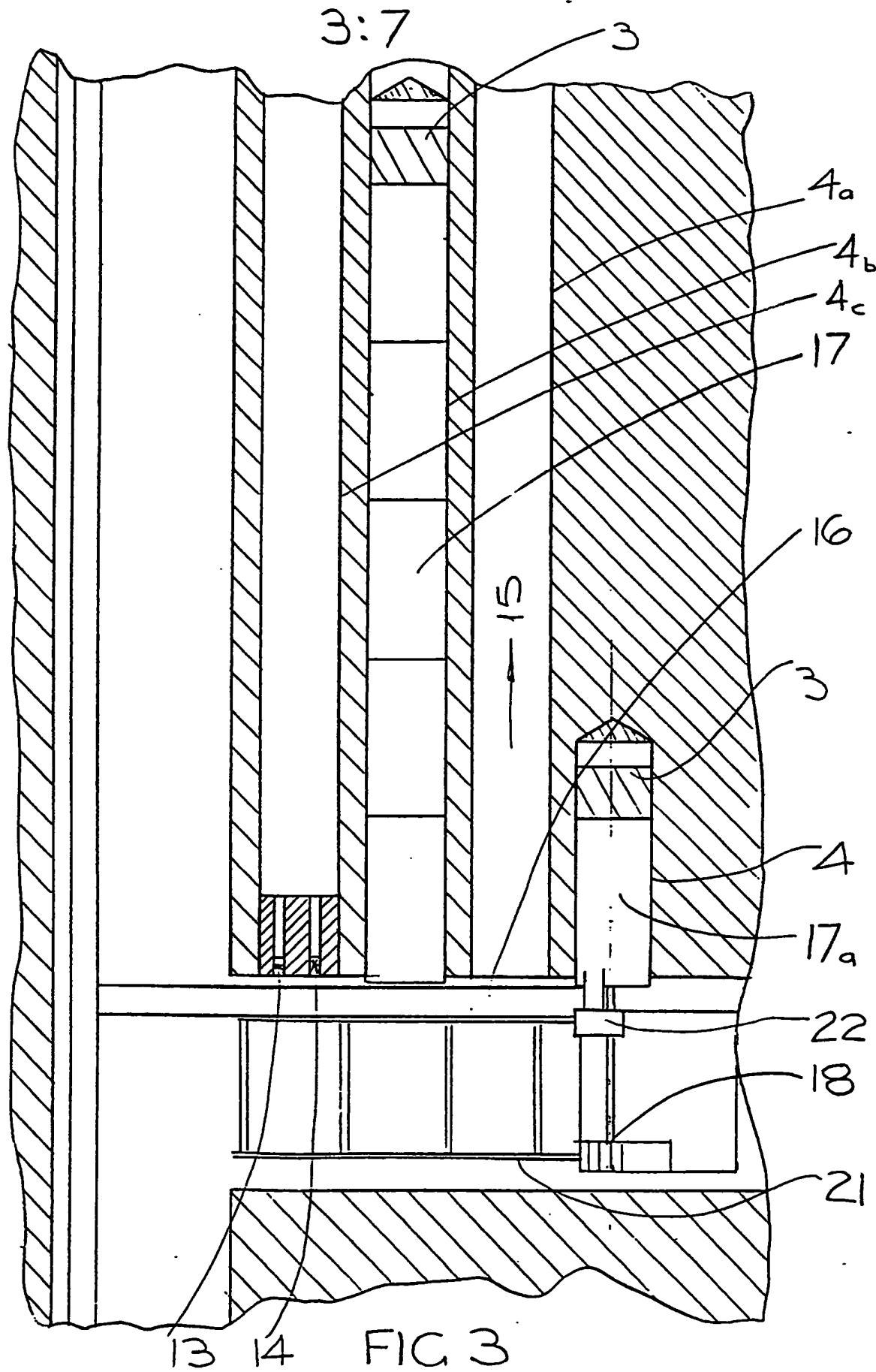


FIG 2



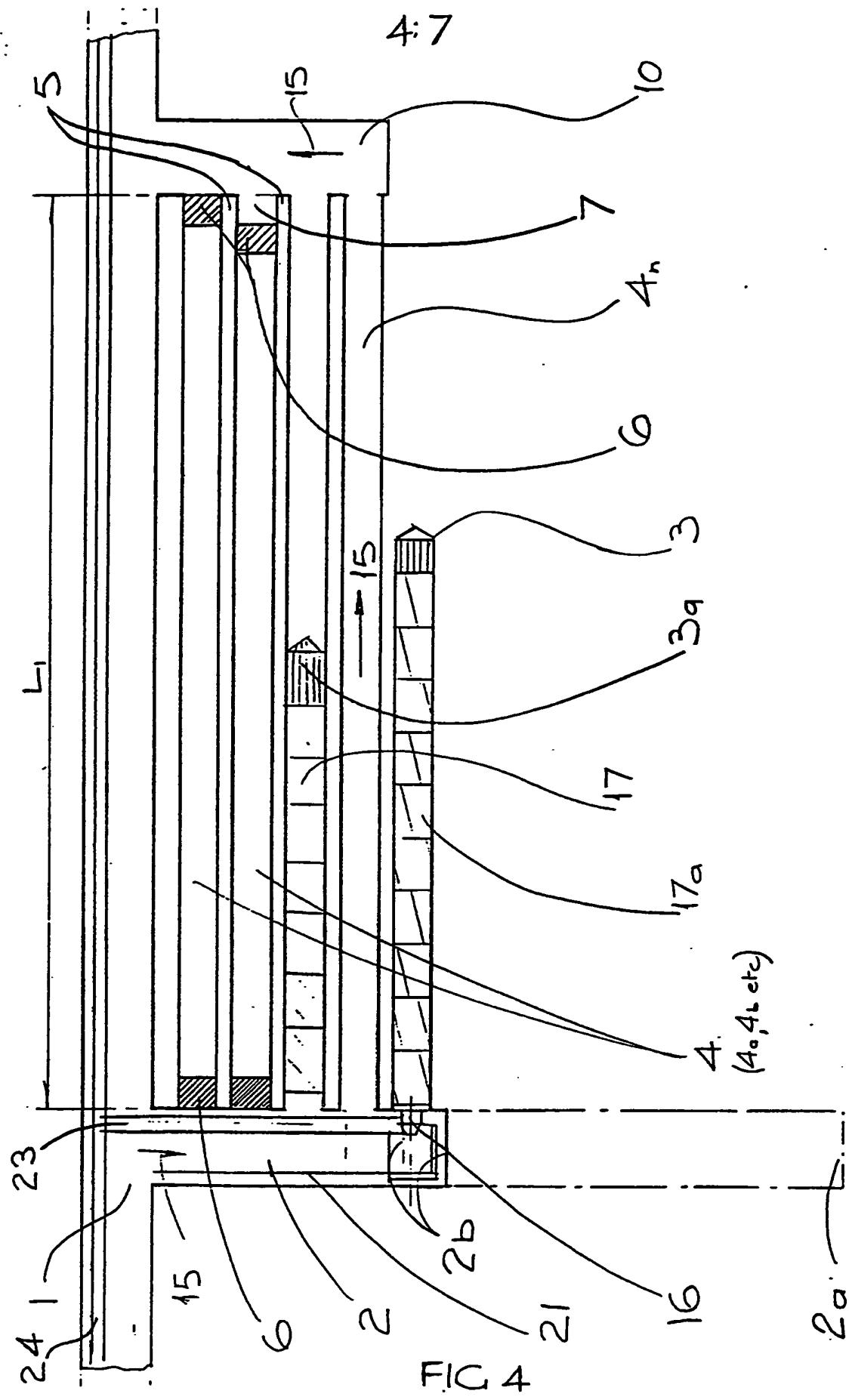
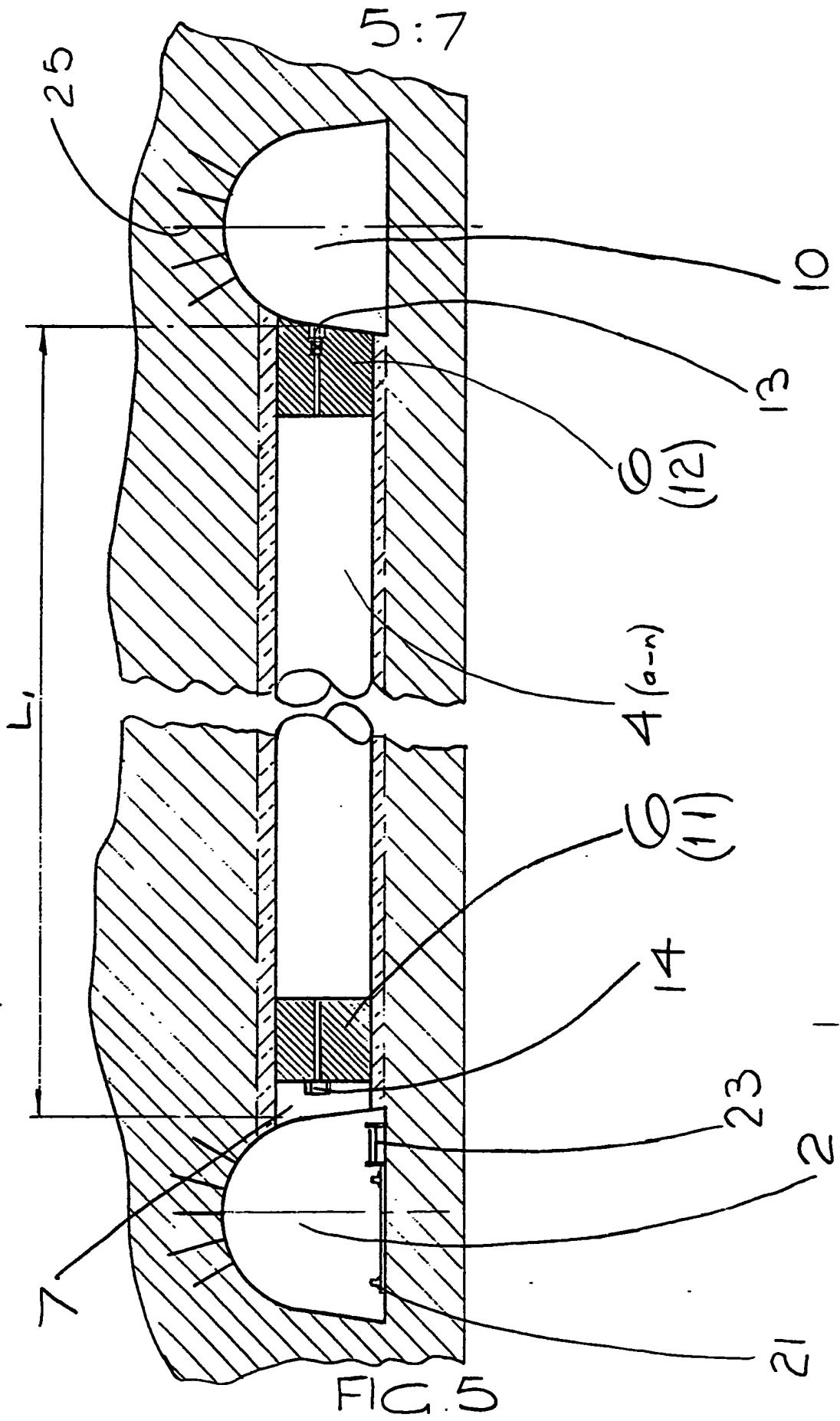
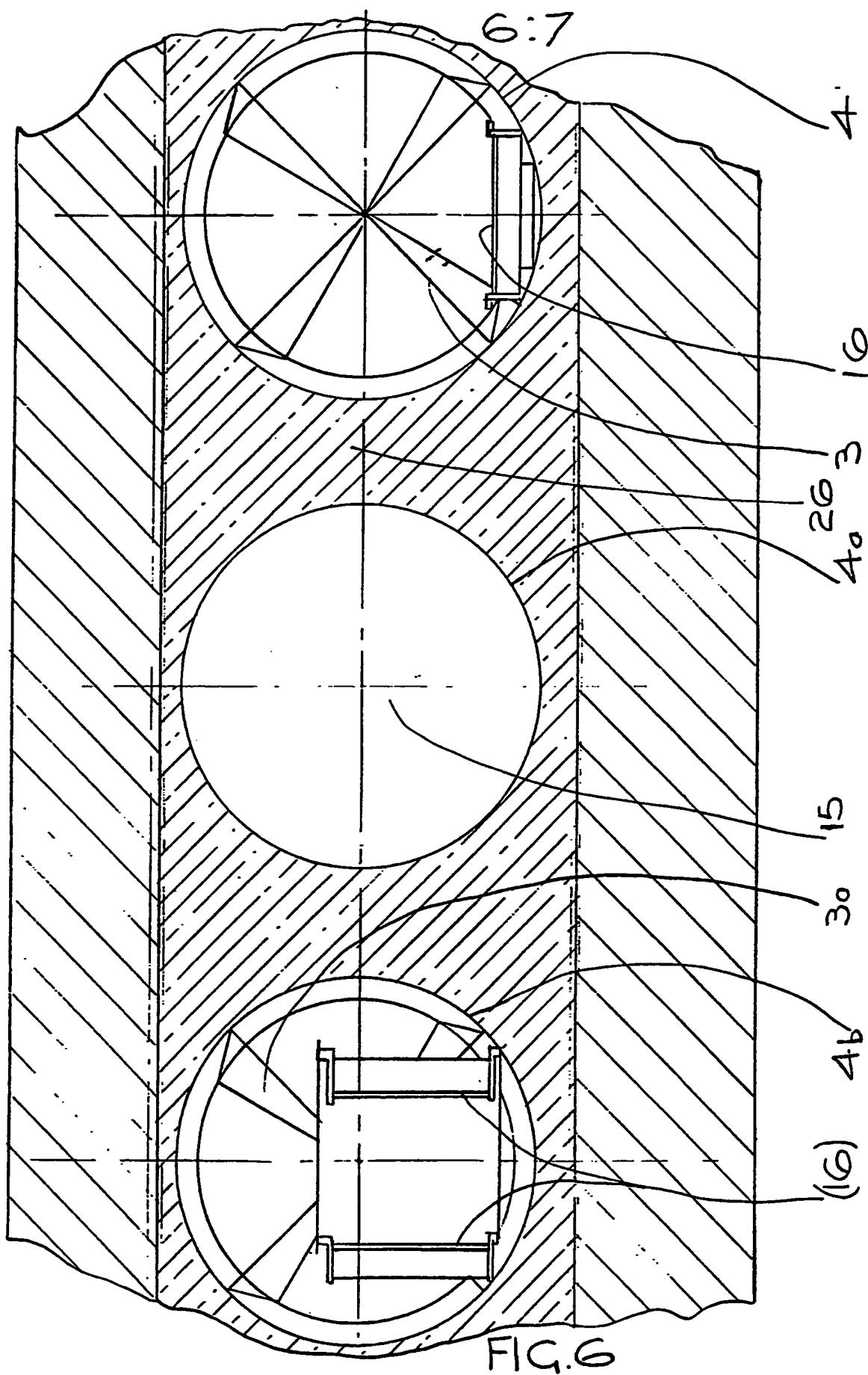
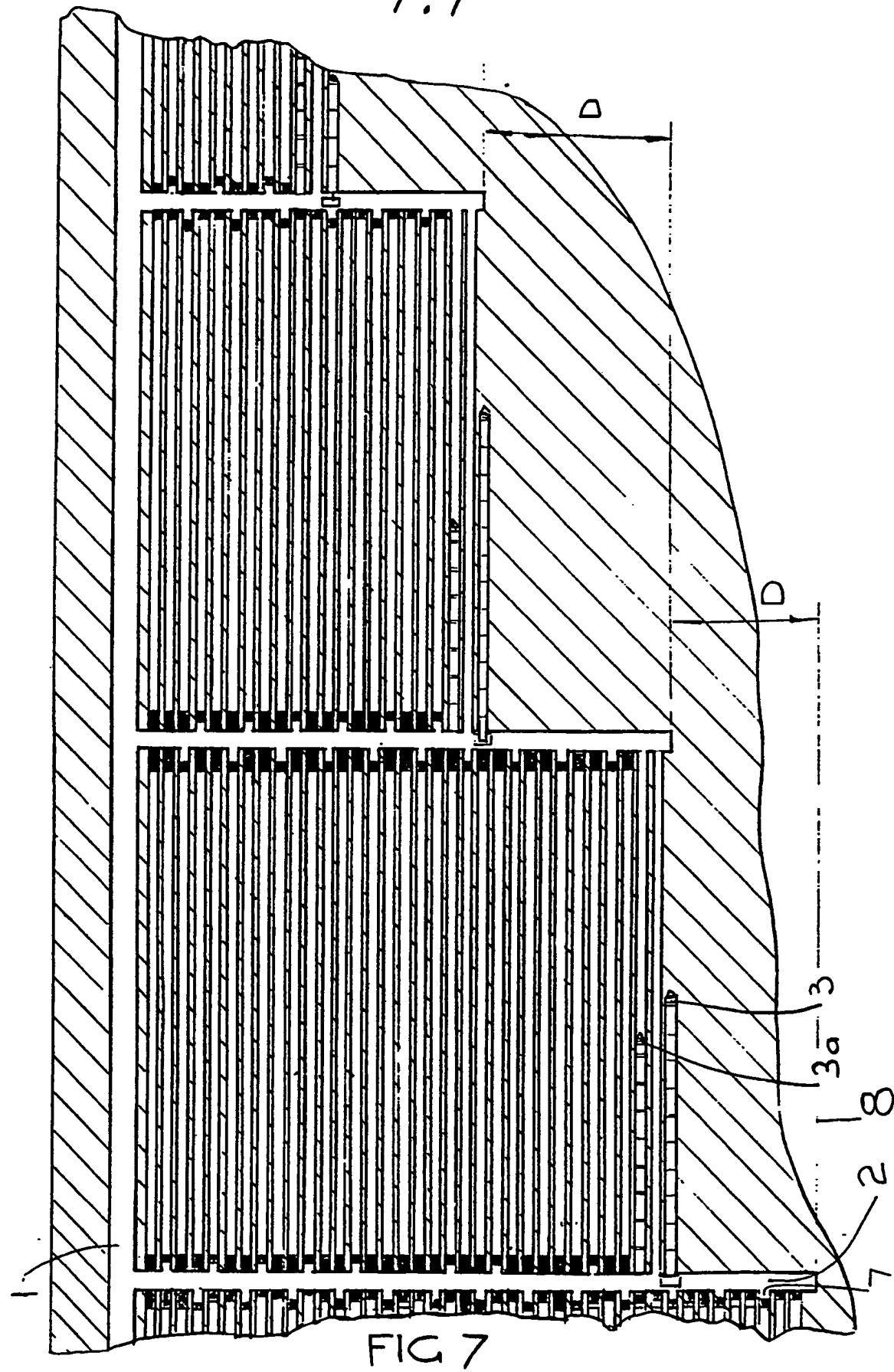


FIG 4





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A METHOD OF MINING COAL BY AUGERING

The process of reaming, augering or otherwise producing holes, of circular or other cross section, for coal or other ore extraction is well known, but not in mining in the modern manner. Its previous uses have been generally for boring pillars or support sections in order to de-stress them and possibly to extract mineral. The same technique has been used for similar reasons on support breasts between a section and its adjacent roadway. Patents also exist for a system of augering vertically between two horizontal roadways or drifts, one at the top and one at the bottom of thick seams, for the purpose of mining coal or other mineral from such seams.

This present invention proposes the use of circular or other shape hole boring in a variety of ways to extract coal from complete districts, whilst leaving support pillars between such bored tunnels to act both as roof supports and containers for possible storage and/or gasification. Our earlier patent application no 8819961.7 sets out to describe how these pillars and holes may be formed using pre-drilled pilot holes,

whereas this present invention shows how conventional augering or cutting with an especially designed machine may be used to good advantage to win coal within similar geomorphic and geological constraints to those currently accepted.

Among the objects of the present invention is a reduction in costs of the major elements:-

- 1) No requirement for arch shaped roadway supports.
- 2) No requirements for Mechanical or hydraulic face supports.
- 3) Easier roadway drivage with immediate coal extraction.
- 4) No requirement for equipment to be salvaged after a district has been fully mined.
- 5) Return to economic "advance" mining with many of the benefits of the "retreat" technique.

Some additional benefits of the proposed system

include:-

- 6) Simplified ventilation.
- 7) Simplified continuous mining
- 8) Simplified storage of underground equipment
- 9) Simplified application of waste storage
- 10) Simplified application of subsequent gasification.
- 11) Simplified adaptation to suit "board" condition or seam collapse.
- 12) Considerably less effect of above seam subsidence.

According to the present invention a variety of bored hole disposition patterns are envisaged to better suit local strata or other conditions. A preferred disposition is so arranged that a sequential series of holes of a diameter or size to suit the seam thickness be produced at an angle to suit strata conditions from both sides of an inby roadway and extend in

depth/length a suitable distance to suit the machinery involved, probably approximately 100 metres, such holes being controlled in direction in the near-horizontal plane, to follow as closely as possible the lie of the seam being worked. As each bored hole is completed, and the boring and conveyor equipment extracted from it in readiness to begin the next hole, that hole just completed is securely plugged with rapid-curing compound in order to form a roadway roof support and gas control locks, such a sequence to be continued until the whole section and/or district has been so mined.

It is further suggested that in order to simplify the overall mining process, said auger/borer drive head unit be itself equipped with an especially designed boring head, and thus be able to use this device to "advance" said inby roadway as each pair of augered/bored holes is completed.

In another embodiment of the present invention, it is proposed that parallel to a main spine or service roadway, a sequential series of holes of a diameter or size to suit the seam thickness, be augered/bored

substantially perpendicular to a constantly advancing 'inby' roadway, the said 'inby' roadway being disposed in similar manner to the main roadway, the said augering/boring to follow as far as practical the near horizontal lie of the seam being mined and be of length/depth to match the normal augering/boring depth limit, at which limit an "outby" roadway will be driven in stages to interconnect said augered/bored holes, as each is completed, leaving the nearest adjacent augered hole open-ended for ventilation and next but one augered hole with its ends securely plugged to form roadway roof support and gas control locks, such a sequence to be continued until the section is completed.

It is further proposed that said nearest adjacent augered hole should in addition to serving as a ventilation tunnel be used to house: auger/borer sections ready for attachment and use in the hole being bored, conveyor sections, or a completed "take up" unit to enable the coal transport conveyor to be constantly extended into the working augered hole whilst being withdrawn from the storage hole. Said nearest adjacent augered/bored hole and/or a suitable projection from it

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could also act as an abutment for a reaction device to "advance" the augering and conveyor drive mechanism forward along the advancing inby roadway in readiness for commencement of augering/boring for the next hole, said augering and conveyor drive mechanism being mounted upon a track laid on the floor of said inby roadway in such a manner as to allow said drive mechanism to be advanced along the inby roadway and to move the auger drive portion in the same plane but substantially perpendicular to said inby roadway, in order to form an auger feed motion, that is to say said auger and conveyor drive unit is made to move with x-y coordinates upon a self-advancing track system.

Further embodiments of the present invention propose that:

- 1) both inby and outby roadways should not have steel or other forms of arch support, but should employ a technique known as rock bolting, which, together with the sealed end of the augered holes, form a safe and adequate local roof support system. However, if, when augering/boring substantially horizontally along a seam and perpendicularly to the inby roadways, the support

pillars formed between each augered hole are found to be, or become, unstable due to the strata break or shear strength or other reason, the holes may be disposed at an "offset" angle other than 90 degrees to the inby roadway, said angle being that which best achieves stability of the pillars most expediently. It follows that the "break" can induce a condition wherein adjacent sections may need to have said augering offset angles of opposite sign, hence the mining pattern between sections would appear as "herringbone pattern." Such a pattern is preferred since it will produce the strongest pillar formation between bored holes and thus better roadway roof support, being likened both to diagonal bracing in mechanical structures and to a substantially less slender column to resist buckling stresses induced by vertical loadings.

- 2) Augered holes with their ends plugged should be so treated such that the plug is not only of sufficient strength and form as to produce a roadway roof support, but should also be capable of being rapid in "curing" time, suitable for gas and/or combustion control, and for the containment of water under pressure in order that such water may subsequently be used for eg

combustion control, district or other form of heating when adjacent bores are being gasified, thus providing a form of geothermal heating, or for dust suppression or other uses.

3) "Inby" roadways may be driven by any one of a number of conventional means, either fully in advance of the augering sequence, such that the section limit is reached, or stage by stage, slightly in advance of the augering process. However, it is proposed herein that the outby roadway may be driven again by any one of a number of conventional means, but in stages only, to break through to the last augered hole, thus reducing the effort required for, and the spoil removed from such drivage to be considerably reduced, when compared with driving such a roadway through unbroken material.

4) The plugging of augered holes may be arranged such that ventilation can be planned and applied to "faces" within a section, from section to section, and from complete sections to districts. Similarly, gasification can be controlled if required to begin at the extreme range of a district and continue in precise

manner back towards the main shaft, if such a course is desirable, more especially since no steel support arches or similar equipment needs to be salvaged from the now completely mined area.

A specific embodiment of this invention will now be described by way of example, with reference to the following drawings in which:-

Fig 1 Shows a plan view of a section being worked with "herringbone" angled holes.

Fig 2 Shows a plan view of several sections worked in herringbone fashions.

Fig 3 Shows a plan view with detail of augering sequence and equipment.

Fig 4 Shows a plan view of a district being worked in single heading advance manner using the system.

Fig 5 Shows a section through a bored hole and its associated "inby" and "outby" roadways.

Fig 6 Shows an end view of an augered/bored hole and the disposition of its associated equipment.

Fig 7 Shows a plan view of multiple heading work.

Considering figure 1:- From a spine or service roadway (1) an 'inby' road (2) (which in the case of the "herringbone" disposition shown is also the main road) is ideally driven stage by stage just in advance of the circular cross section holes (4 - 4n) produced one each side of the inby road (2) by the augering/boring head (3) such boring head being caused to bore a hole of depth, L representing the fullest practical extent of travel of such a machine and likely to be approx 100 metres. Said holes (4 etc) being so spaced as to leave a pillar or column of coal (5) as a support between said holes such that when the open end of said holes (4 etc) are securely plugged, a further support for the inby roadway (2) is produced. It follows that if said plug (6) is in some cases finished perpendicular to the line of the bore into which it is placed, a space to form a refuge hole (7) is formed automatically between said plug (6) and the edge of the inby roadway (2). When said inby roadway (2) has been driven to the

extent of the section being mined (8) and all the circular holes (4 etc) associated with it are completed, all the machinery is withdrawn from this section and a new inby roadway is begun, and at a distance apart sufficient to leave a suitable pillar of coal (9) (Fig 2) between adjacent ends of holes (4 etc) when worked out to length L.

Considering figures 3 - 7:- from a spine or service road (1), an "inby" roadway (2) is driven either full depth of section (2a) or stage by stage (2b) in association with the subsequent operation of hole augering/boring, said inby roadway (2) being substantially perpendicular to the main road (1). An auger/borer (3) is caused to bore a hole (4) progressively to its fullest extent over a length (L1) and then withdrawn to advance along inby roadway (2) a distance sufficient to form a support pillar (5) between adjacent augered/bored holes and set to bore again over a length (L1) and so on sequentially until the whole section has been thus bored. As the first hole (4) has been completed and work begins on the second augered hole (4a) an outby roadway (10) is driven forward to interconnect with the augered/bored

hole (4) (4a) and so on, progressively through the section. As the third augered/borer hole (4b) is begun, both ends of the hole (4b) are securely and substantially plugged (6), in order to form:-

- 1) support elements (11) for inby and (12) for outby roadways.
- 2) gas or combustion control plugs (13), or
- 3) controlled ventilation path (15)
- 4) water and/or pressure reaction plugs (14) for use as later described.
- 5) refuge hole (7) by setting back said plug (6) from the inby road (2).

As augering/boring progresses through the section, the bored hole adjacent to that which is under construction will be used as a ventilation path (15) and may, if desired, be used as a storage area for sections of the auger/borer column (17), from whence each such section

can be withdrawn and attached to that section already in the hole by any known means and between the auger/borer working column (17a) and its driving head (18), when said head is withdrawn to the start point, having reached the limit of boring for each element (17) of the auger/borer (3).

Similarly, sections of conveyor (16) or track or other equipment may be stored in the hole adjacent to the working hole. However, if preferred, the storage (19) and plugged (20) holes may be setback by one leaving the adjacent hole to that being worked purely for ventilation, or any similar combination may be used. If the inby roadway is driven in advance as shown at 2a, a track system (21) may be laid down upon which the auger drive head (18) and the conveyor drive head (22) and other equipment may be mounted in such a manner as to permit motion of both heads (18 and 22) in the y axis direction, and subsequent motion of the auger/borer drive head (18) in the x axis direction in order to auger said holes. It follows that length of motion in the x axis of the auger drive head (18) is arranged to suit the insertion and subsequent use of standard auger/borer elements (17) and that the use of

two auger/borer units (3 and 3a) will enable the full length of adjacent holes to be used as storage and that the x motion of the head will allow removal from storage, and fitting to the working column of one auger/borer element (17) at a time, whilst one auger/borer unit (3a) is at the far end of the adjacent storage tunnel, but being brought closer to the working area as each auger element (17) is withdrawn from storage and attached to the working column (17a). When all stored elements (17) have been used and the hole being worked has reached its limit of length, the auger/borer drive is retracted back across the inby roadway (2) and advanced along the roadway (2) in readiness to begin to produce a new hole using the auger/borer unit (3a) upon its removal from the storage hole.

Further embodiments of this invention allow:

- 1) provision of double or multiple heading ie working in two or more adjacent sections at the same time, as indicated in Fig 7, each section being set back by a predetermined distance (D) to permit the inby (2)/outby (10) roadways to interconnect the augered/bored hole

adjacent to that being worked.

2) provision for controlled gasification and/or water heating eg district heating as appropriate using some of the stored water for injection into the combustion zone for use as part of the "burning" rate control technique, or for complete or partial production of "producer gas."

3) provision for controlled waste disposal wherein such waste material will be consolidated or otherwise packed into the augered/bored holes (4 etc) before plugging as at (6). Such waste filled holes may where appropriate be later gasified by any one of a number of means if so desired.

It follows that in order to remove the coal produced as each hole (4) is extended, conveyors (16) in the hole being worked must be continuously extended following precisely the auger/borer (3) and transport mineral back to another extensible conveyor (23) in the inby roadway (2), such that said conveyor (23) will be able to advance as the auger/borer and conveyor drive head advance, and in turn transport said mineral backward to

the main conveyor (24) in the main roadway (1) and in due course to the pit head.

Therefore in summary:- In contrast to the conventional longwall mining techniques currently favoured by British Coal and others, this invention proposes a completely different method of mining coal or other minerals. This invention proposes:

1. A method of mining wherein a sequential series of parallel holes be produced (yielding coal) by auger, borer or especially designed machine one after another from one or both sides of an inby roadway itself being driven from a main or spine roadway either in stages to match the progress of the sequential hole boring or in advance and to the full extent of the section to be worked or any intermediate stage; said sequentially bored holes in sequence being caused to follow the near horizontal lie of the seam and be direction controlled for this purpose, and be of near circular or other cross section from which coal may be continuously extracted to be discharged onto a series of continuously extending conveyors, arranged to transport

said coal to a main roadway conveyor and onward to the point of despatch, said sequential holes being spaced apart by a predetermined distance to form a support pillar of residual coal in order to support the roof of the working area and when said sequential holes are securely plugged form a support for the inby and outby roadways, disposed one at each end of the newly bored sequence of holes, subject to break and/or other strata conditions, the plan pattern of sequentially bored holes may vary progressively from perpendicular to the inby and parallel to the spine or main roadway to disposition at an angle of 45 degrees in plan to both inby and main roadways and from one or both sides of the inby roadway or any combination of this, said 45 degree disposition would enable the strongest support pillar to result from a given hole to hole spacing, said mining method would enable said sequentially bored holes to be used for waste packing prior to plugging, water storage or utilization and/or gasification as outlined in our prior patent application 8819961.

It is further proposed that the augered/bored holes may, before plugging, be packed with consolidated waste (either mining or other) bonded with a rapid cure

agent, such as cement, to form solid support columns, which would in turn allow the pillar of coal originally left between the augered/bored holes to be itself augered/bored to still further increase the coal yield. It is foreseen that such an extraction operation would best take place in the "retreat" manner, thus bringing all the mining, conveying and other equipment used in this process closer to the pit bottom.

CLAIMS ..

1. A method of mining wherein a sequential series of parallel holes be produced (yielding coal) by auger, borer or especially designed machine one after another from one or both sides of an inby roadway itself being driven from a main or spine roadway either in stages to match the progress of the sequential hole boring or in advance and to the full extent of the section to be worked or any intermediate stage; said sequentially bored holes being caused to follow, during boring, the near horizontal lie of the seam and be direction controlled for this purpose, and be of near circular or other cross section from which coal may be continuously extracted to be discharged onto a series of continuously extending conveyors, arranged to transport said coal to a main roadway conveyor and onward to the point of despatch, said sequential holes being spaced apart by a predetermined distance to form a support pillar of residual coal in order to support the roof of the working area and when said sequential holes are securely plugged form a support for the inby and outby roadways, disposed one at each end of the newly bored sequence of holes, subject to break and/or other strata

conditions, the plan pattern of sequentially bored holes may vary progressively from perpendicular to the inby and parallel to the spine or main roadway to disposition at an angle of 45 degrees in plan to both inby and main roadways and from one or both sides of the inby roadway or any combination of this; said 45 degree disposition would enable the strongest support pillar to result from a given hole to hole spacing.

2. A method of mining wherein a sequential series of holes be

augered substantially perpendicular to and initiating in an inby roadway, driven from a main or spine roadway such that said augered/bored holes follow as nearly as possible the "lie" and thickness of the coal seam being worked, said augered/bored holes being determined in length by the practical limit of said augering technique at which limit an outby roadway will be driven to interconnect said augered/bored hole, thus forming a four sided tunnel, said augered holes are separated one from another by a predetermined amount to leave a pillar as support between each augered hole; similarly the hole, two-removed from that being worked will have its ends securely and substantially plugged,

forming a support system for said inby and outby roadways, whilst the hole adjacent to that being worked will be left temporarily unplugged as a ventilation passage, serving the section; as each hole is augered/bored a conveyor is caused to move in conjunction with said auger/borer in order to remove coal from the working face and deposit it via a similarly extending conveyor, in the inby roadway, upon the main removal conveyor, in the main or service roadway.

3. A method of mining as in claims 1 and 2, wherein said auger/borer, its boring head, associated extending elements and said extending conveyor may have some parts duplicated and be stored in one of the previously augered/bored holes (before plugging) from whence they may be removed, element by element, as they are required in the working hole, or, in the case of the conveyor, this may be of the self-compensating type, such that the whole length may be stored in working mode and used to extend into the working hole whilst still in one continuous length.

4. A method of mining as in claims 1 - 3 wherein the conveyor drive head and the auger/borer drive head are mounted upon an extendable track system in such a manner that both can be advanced along the inby road and the auger/borer drive may be moved perpendicularly to this motion, in order to feed said auger/borer and its subsequent extending elements into said augered/bored holes as they are lengthened, and by deriving an abutment which may be associated with a previously augered/bored hole, said conveyor and auger drive heads may be made to "self advance" in the normal mining manner and at the appropriate time.

5. A method of mining as in claim 1 - 4 wherein provision is made for such augering/boring to take place simultaneously in double or multiple headings in adjacent sections, such headings being in stepped form, allowing adjacent section headings to be set back by an appropriate distance in order that the inby/outby roadways may interconnect the augered hole adjacent that being worked in each case.

6. A method of mining as in claims 1 - 5 wherein said augered/bored holes may be set off at a plan angle

other than 90 degrees to its inby roadway, although still running parallel to the coal seam being mined, in order to take best advantage of seam shear strength, or the lie of the "break", or other strata condition, and improve the strength of the roof support pillars and/or the efficiency of coal extraction. Said angled augering/boring may be so arranged as to vary the angles from each inby/outby roadway and thus produce a herringbone like pattern of augered holes such that the listed benefits may be greater.

7. A method of mining as in claims 1 - 6, wherein said plugged holes may, at the time of plugging, or subsequently, be fitted with the appropriate valves and connections in order that gasification of the remaining coal may be undertaken in a precisely controlled manner, further combustion control may be achieved if some or all of the said plugged holes, with or without linings are at an earlier stage filled with water for this purpose, some or all of said water may alternatively be used for above ground heating as for example in a district heating scheme, both said gasification and district heating being previously known and tried techniques, or for the production

underground of producer gas.

8. A method of mining as in claims 1 - 7 wherein the face of the plug in the bored holes is set back from its intersection with the inby roadway by a suitable distance to form a refuge hole for occupation by workers in an emergency, said refuge holes to be disposed at regular and frequent intervals along the inby/outby roadways as required.

9. A method of mining as in claims 1 - 8 wherein the inby and outby roadways may have their support derived from a combination of said bored hole plugging and in roadway rock bolting or steel arch supports as preferred.

10. A method of mining as in claims 1 - 3 and in claims 4 - 7 of our patent application 8819961 wherein by dint of the use of rock bolted roadway roofs and the roadway roof support derived from plugging of the augered holes, no other roof support of any kind need be used, left underground or salvaged when mining is completed.

11. A method of mining as in claims 1 - 6 wherein provision is made before plugging to fill the augered/bored holes with consolidated waste material, suitably bonded with a rapid-curing binding agent, such as cement, in order to form roof support elements and thus permit the pillars of coal originally remaining between the augered/bored holes to be themselves augered/bored or otherwise removed, to further increase the coal yield; such a process would be beneficially carried out in retreat manner, thus causing the auger/borer conveyor and other equipment used in coal extraction to be brought progressively closer to the pit bottom.

12. A method of mining as in claims 1 - 11 and as described in the attached specification and drawings.